NONPROVISIONAL PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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BOX PATENT APPLICATION

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RULE §1.53(b)

JC511 U.S. PTO
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Director of the U.S. Patent and Trademark Office
Washington, D.C. 20231

Sir:

Transmitted herewith for filing under 37 C.F.R. §1.53(b) is the nonprovisional patent application

For (Title): MULTIPOINT DIGITAL SUBSCRIBER LINES WITH HOME DATA NETWORK ABILITY

By (Inventors): Roman VITENBERG

- ☒ Formal drawings (Figs. 1-12; 12 sheets) are attached.
- ☐ A Declaration and Power of Attorney is filed herewith.
- ☐ An assignment of the invention to _____ is filed herewith.
- ☐ An Information Disclosure Statement is filed herewith.
- ☐ A statement to establish small entity status under 37 C.F.R. §§1.9 and 1.27 is filed herewith.
- ☐ A Preliminary Amendment is filed herewith.
- ☐ Please amend the specification by inserting before the first line the sentence --This nonprovisional application claims the benefit of U.S. Provisional Application No. _____, filed _____.--
- ☒ Priority of foreign application(s) No. 134402 filed February 6, 2000 in Israel is claimed (35 U.S.C. §119). No. 136782 filed June 15, 2000 in Israel is claimed (35 U.S.C. §119).
- ☐ A certified copy of the above corresponding foreign application(s) is filed herewith.
- ☒ The filing fee is calculated below:

CLAIMS IN THE APPLICATION AFTER ENTRY OF ANY PRELIMINARY AMENDMENT NOTED ABOVE

FOR:	NO. FILED	NO. EXTRA	SMALL ENTITY RATE	SMALL ENTITY FEE		OTHER THAN A SMALL ENTITY RATE	OTHER THAN A SMALL ENTITY FEE
BASIC FEE				$ 345	OR		$ 690
TOTAL CLAIMS	25 - 20	= 5*	x 9 =	$45	OR	x 18	$
INDEP CLAIMS	3 - 3	= 0*	x 39 =	$-----	OR	x 78	$
☐ MULTIPLE DEPENDENT CLAIMS PRESENTED			+130 =	$	OR	+260	$
			TOTAL	$390	OR	TOTAL	$

* If the difference is less than zero, enter "0".

- ☒ Check No. 106544 in the amount of $390.00 to cover the filing fee is attached. Except as otherwise noted herein, the Director is hereby authorized to charge any other fees that may be required to complete this filing, or to credit any overpayment, to Deposit Account No. 15-0461. Two duplicate copies of this sheet are attached.
- ☒ This application is entitled to small entity status. DO NOT charge large entity fees to our Deposit Account.

Respectfully submitted,

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10/98

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Application Information

Title Line One::	MULTIPOINT DIGITAL SUBSCRIBER LINES
Title Line Two::	WITH HOME DATA NETWORK ABILITY
Title Line Three::	
Title Line Four::	

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Continuity Information

>This application is a::
Application One::
Filing Date::
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Prior Foreign Applications

Foreign Application One:: 134402
Filing Date:: February 6, 2000
Country:: Israel
Priority Claimed:: yes
Foreign Application Two:: 136782
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Country:: Israel
Priority Claimed:: yes
Foreign Application Three::
Filing Date::
Country::
Priority Claimed::

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Roman VITENBERG

Application No.: New U.S. Patent Application

Filed: June 22, 2000 Docket No.: 106544

For: MULTIPOINT DIGITAL SUBSCRIBER LINES WITH HOME DATA NETWORK ABILITY

PRELIMINARY AMENDMENT

Director of the U.S. Patent and Trademark Office
Washington, D. C. 20231

Sir:

Prior to initial examination, please amend the above-identified application as follows:

IN THE CLAIMS:

Please amend claims 4, 6-8, 13, 15-17, 22 and 25 as follows:

Claim 4, line 1, change "any one of Claims 1-3" to --Claim 1--.

Claim 6, line 1, change "any one of Claims 1-4" to --Claim 1--.

Claim 7, line 1, change "any one of Claims 1-6" to --Claim 1--.

Claim 8, line 1, change "any one of Claims 1-14" to --Claim 1--.

Claim 13, line 1, change "any one of Claims 10-12" to --Claim 10--.

Claim 15, line 1, change "any one of Claims 10-13" to --Claim 10--.

Claim 16, line 1, change "any one of Claims 10-15" to --Claim 10--.

Claim 17, line 1, change "any one of Claims 10-13" to --Claim 10--.

Claim 22, line 1, change "any one of Claims 19-21" to --Claim 19--.

Claim 25, line 1, change "any one of Claims 19-24" to --Claim 19--.

REMARKS

Claims 1-25 are pending. By this Preliminary Amendment claims 4, 6-8, 13, 15-17, 22 and 25 are amended to eliminate multiple dependencies. Prompt and favorable examination on the merits is respectfully solicited.

Respectfully submitted,

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MULTIPOINT DIGITAL SUBSCRIBER LINES WITH HOME DATA NETWORK ABILITY

FIELD OF THE INVENTION

The present invention relates generally to data and voice communications over digital subscriber lines consisting of twisted pair telephone cables. More particularly, the invention concerns a system and devices for multipoint communication in a splitterless asymmetrical digital subscriber line (ADSL) system.

BACKGROUND OF THE INVENTION

Digital Subscriber Line is a new communication technology that allows existing twisted pair Cable Telephone Network to be converted into a high-performance Multimedia Digital Network for multimedia and high-speed data communications with ability to provide to every subscriber high speed data communication that include many new services as Video-on-demand, Conference VideoPhone, HDTV Broadcast, Digital Hi Fi Audio, Fast Internet and others.

Digital Subscriber Line technology includes several types of xDSL systems with different patterns of downstream and upstream data bit rate: Symmetrical Digital Subscriber Line (SDSL), Asymmetrical Digital Subscriber Line (ADSL), Very high speed Digital Subscriber Line (VDSL) and others.

These international standards define the frequency bands permitted for downstream (in the direction from a Central Office (CO) of a communication service provided to home modem) or of upstream (in direction from home modem to CO) transmission for different DSL systems. As a result, different DSL systems may operate properly on the different twisted pairs of the same telephone cable.

Fig. 1 illustrates frequency band allocation plan for DSL system in accordance with ITU regulation. A *"Plain Old Telephone Service"* (POTS) occupies voice frequency band **101** up to a frequency of 4 kHz. An Asymmetric Digital Subscriber Line (ADSL) uses digital multitone (DMT) line signals for communication between subscriber equipment and central office (CO) of telephone station. An ADSL Equipment of the CO transmits downstream data by modulation of about 200 tones in frequency band **105** from 200 kHz to 1100 kHz and receives about 30 tones of upstream data in frequency band **103** from 28 kHz to 140 kHz. ADSL systems are able to transmit downstream data with speed up to 10 Mb/s and upstream data with speed up to 1 Mb/s. ADSL was specially developed for long cable lines with length up to 4.5 km.

In VDSL system data may be transmitted with a much higher bit rate: downstream data up to 56 Mb/s and upstream data up to 26 Mb/s but works only on short cable line of up to 1.5 km.

As shown on Fig. 1 four frequency bands are defined for the VDSL system: two for downstream transmission (one band **107** from 0.3 MHz to 3.0 MHz and the other band **109** from 5.2 MHz to 7.5 MHz), and two bands for upstream transmission (one band **111** from 3.0 MHz to 5.2 MHz and another band **113** from 7.5 MHz to 12 MHz). Depending on cable length and necessary bit rate these bands may be partially or completely used. VDSL may be realized with DMT line signal and with CAP modulation.

The most wide-spread ADSL use is in point-to-point connected circuit. Such a system includes an ADSL modem on each end of the twisted pair telephone line, creating three information channels – a high speed downstream (central office to end user) channel, a medium speed upstream (end user to central office) channel, and a POTS (*"Plain Old Telephone Service"*) channel. The POTS channel is separated from the ADSL modem by filters, thus guaranteeing uninterrupted POTS, even if the ADSL circuit fails.

Two variants of ADSL systems are available today: full-rate ADSL in accordance with the T1E1.413 or ITG G.992.1 standards and *"splitterless"* ADSL

in accordance with the ITU G.992.2 standard. Full-rate ADSL uses POTS splitters to separate the POTS channel from the ADSL data signals. A POTS splitter is installed at each end of the line and includes a low-pass filter for separating out POTS telephone voice communication signals and a high-pass filter for separating out data communication signals.

The POTS splitter divides the subscriber line into two separate twisted pairs – one for data communication (ADSL) and one for telephone voice communication signals (POTS). As a result, the existing two-wire internal house telephone wiring is not usable for ADSL. New wiring must be installed from the splitter to the modem, resulting in increased installation cost.

Splitterless ADSL can be installed without the need for additional home wiring. In this case, the ADSL modem includes a high-pass filter that rejects the POTS telephone voice communication signal, while every telephone instrument in the house is connected to the telephone line through a low-pass microfilter that rejects the ADSL data signals. A splitterless ADSL system is advantageous in that it is a *"Play and Plug"* system. A customer does not need any special service from his telephone company to install the ADSL home equipment. What is needed therefore is an ADSL home modem and a number of microfilters (according to the number of telephones in the house) and to plug those devices into existing telephone connectors. Given the ease of connection several PC (personal computer) manufacturers include splitterless ADSL modems (G.LITE modems) within the PCs motherboards and also supply the several microfilters with the PC.

Fig. 2 is a block diagram illustrating a prior art splitterless ADSL system generally designated **201**. A number of subscriber premises **203** are coupled to a central office (CO) **209** by a telephone cable **217** comprising a plurality of twisted pair subscriber telephone lines **207**. At the subscriber premise **203** there are customer premises equipment including personal computers (PC) **225** (two in this specific example), printer **227**, fax **221** and telephone devices **223**. One PC **225** is connected to another PC **225** and to printer **227** by parallel port cables **229** constituting together a digital home network. A NDSL modem is connected

directly to telephone line **207** and by an Ethernet cable **224** to one of the PCs **225**. Fax **221** and telephone device **223** are connected to telephone line **207** by microfilters **219**. CO **209** includes an ADSL Office Equipment **211**, data switch **235**, linked to a data network **215** and a voice switch **237** linked to a voice network **213**. Each twisted pair subscriber telephone line **207** is coupled to a POTS splitter **231**, which is coupled to the voice switch **237** and to an ADSL office modem **233**.

Voice communications passing through voice switch **237** are passed through POTS splitter **231** and applied to twisted pair **207** as baseband signals. Data communications passing through data switch **235** are modulated at a frequency range higher than that of the baseband POTS signals and passed through POTS splitter **231** and applied to twisted pair **207**. Since the data communications are transmitted at a different frequency range than the voice communications, frequency-division multiplexing (FDM) allows simultaneous transmission of both voice communications (POTS) and data communications over a single twisted pair **207**.

A standard ADSL system has some shortcomings. For one, an ADSL system needs to be always connected. It means that ADSL modem continuously transmits and receives DMT signals regardless whether information is transmitted or not. As a result, a plurality of ADSL modems of the Central Office work continuously and consume extensive energy. Additionally, at the other end, only one ADSL home modem may be connected to the telephone line in the home because frequency bands of upstream and downstream are always busy. In the USA, this has become a problem as about 20 million subscribers have more than one PC inside the home. In case of two or more PCs in the home have internal ADSL modem, only one of them may be physically connected to the telephone line. Every time a customer wants an access to the Internet from another PC, he must connect this PC to the telephone line and disconnect other PCs.

Another problem is that existing splitterless ADSL systems do not support communication between several computers within the home. It means that a

subscriber must have an additional home data network like Ethernet and additional network equipment inside their PCs. A further problem resides in that existing ADSL home modems may not support future VDSL systems. A VDSL system is expected to become widespread over the coming years. Telecommunications are expected to replace existing ADSL Central Office equipment with new VDSL equipment, which will be able to support a much higher data bit rate.

SUMMARY OF THE INVENTION

The present invention is directed to a system and modems for multipoint communication in a splitterless asymmetric digital subscriber line (ADSL) system. The system of the present invention includes at least one subscriber premise (*"SP"*) and a central office of a telephone communication provider (to be referred to herein as *"Central Office"* or *"CO"*). The home may be a home residence, a small office, etc. In the system of the invention the subscriber premise and the Central Office are connected by a twisted pair subscriber telephone line. The subscriber premise in accordance with the invention, comprises a plurality (two or more) of NDSL (network DSL) modems. Each NDSL modem within the subscriber premise may be directly connected to the same home telephone line and may communicate with any other home NDSL modem, in the same premise, or with the office xDSL (ADSL or VDSL) modem. In accordance with the present invention, the multipoint NDSL system provides not only data and voice service to and from said premise, but also network data communication within the premise

The mode of communication in accordance with the invention for internal home communication through the home network is different than that between the NDSL modem and the Central Office xDSL modem.

In accordance with the invention there is thus provided a communication system comprising:

- a central office (CO) of a communication service provider and at least one subscriber premise (SP), each SP being linked to a CO by a subscriber-associated communication line comprising a twisted pair telephone line;

- at least one xDSL modem in each CO coupled to said subscriber-associated communication line; and

- a plurality of communication devices in each SP, said devices comprising one or more telephone devices connected to the communication line and at least one network DSL (NDSL) modem associated with a computerized device the NDSL modem being connected to said communication line; each of said modems having an upstream transmitter and a downstream receiver for communication with the CO and an upstream of transmitter and an upstream receiver for communication with other NDSL modems within the SP.

The computerized devices associated with the NDSL modem may be selected from a variety of such devices which can transmit or receive digital data. These include computers, particularly personal computers, as well as other devices which can receive, transmit or store digital data or respond to such data including: a video recorder; a home television, e.g. a high definition television (HDTV); and a variety of home appliances, which can respond to digital command packets such as electronic locks, closeness with an electronic control module, a cooker with an electronic control module and others. The NDSL modem may be an independent device coupled to the computerized device, or may be integral therewith.

The NDSL modem comprises also a means for transmitting a control signal to which the CO modem is not receptive and which signals at least one other NDSL modem to be ready to receive data packets. Such a controlled signal is typically at a frequency not used for communication between the NDSL modem and the CO modem, e.g a DMT signal.

The present invention also provides a local network installed in premises of a subscriber of a communication service, the network being linked to an xDSL modem of a central office (CO) of a communication service provided by a communication line comprising a twisted pair telephone line, the network comprising:

a plurality of communication devices comprising one or more telephone devices connected to the communication line and at least one network DSL

(NDSL) modem associated with the NDSL modem being connected to said communication line; each of said modems having an upstream transmitter and a downstream receiver for communication with the CO and an upstream of transmitter and an upstream receiver for communication with other NDSL modems within the SP.

The present invention still further provides a home network DSL (NDSL) modem comprising:

an upstream transmitter and a downstream receiver for communication with an xDSL modem placed at a central office (CO) of a communication service provider through a twisted pair telephone line linking the NDSL modem and the xDSL CO modem, and comprising an upstream transmitter and an upstream receiver for communication with other NDSL modems included within the same subscriber premise.

In accordance with one embodiment of the invention, the communication between the NDSL modem and the office ADSL modem is realized by the application of the ADSL communication standard – FDM (frequency-devising-multiplex) duplex protocol, during short communication cycles (communication cycles initiated by a computer in the SP prompting the NDSL modem to connect to an Internet service provider or to any other computer network (ISP). An NDSL modem may then connect to the telephone line and activates a standard ADSL communication protocol (e.g. in accordance with ITU G.992.2) to establish communication with the CO ADSL modem. Upon downloading of requested data, e.g. an Internet page, the NDSL modem disables the ADSL office modem and disconnects from the telephone line. The ITU G.002.2 standard provides for several special commands for disabling the CO modem, which may be employed by the NDSL modem to assume communication, without any change in existing CO ADSL equipment.

During data exchange with the CO according to the above embodiment, downstream data transmits at a frequency within the ADSL downstream frequency band **105**, and upstream data transmits at a frequency within the ADSL upstream

frequency band **103** (see Fig. 1). When data is not transmitted between the CO and any of the NDSL modems, the ADSL upstream frequency band **103** may be used for communication with the SP network.

Data communication with the SP network may be established between any two NDSL modems, performing part of or associated with a home computer (typically a personal computer – *"PC"*). In this case a half-duplex mode of communication may be used: one of the NDSL modems transmits the data at a frequency within the ADSL upstream frequency band **103** and another ADSL modem thus receives data at this frequency. The information exchange between the two NDSL modems is then realized by transmitting data packets in two directions. A control signal that is necessary for establishing connection and to properly transfer packets of a translation protocol may be a digital control tone that is not used in standard ADSL transmission and to which standard CO ADSL modems are not receptive.

In accordance with another embodiment of the invention, ADSL upstream band **103** and VDSL upstream bands **111, 113** are employed for data communication in a half-duplex mode within the SP network. In accordance with this embodiment of the invention an NDSL modem comprises universal ADSL/VDSL transmitter, which may transmit DMT line signals in the ADSL upstream frequency band **103**, as well as in VDSL frequency bands **111, 113**. The NDSL modem of this embodiment comprises also an additional VDSL upstream receiver. The universal ADSL/VDSL transmitter and the additional VDSL downstream receiver, may be used also for communication with a VDSL CO modem, replacing the standard CO ADSL modems. Thus, in accordance with this embodiment, the SP equipment is thus *"VDSL-ready"*, namely it is ready for future expected upgrade of Central Office equipment from current ADSL modems to VDSL modems.

In accordance with yet another embodiment of the invention, the SP comprises one or more N.LITE modems which may communicate through the home networks with other modems using the ADSL upstream frequency band.

N.LITE modems may be used for a connection to home data network devices such as a printer, scanner and others, which do not need to directly link to the CO.

In accordance with a further embodiment of the invention, the SP comprises one or more N.LITE set-top boxes that may communicate, through the home network, with other N.LITE set-top boxes using the ADSL upstream frequency band. An N.LITE set-up box comprises, by one embodiment, an N.LITE modem and an RF (radio frequency) transceiver, which supports radio communication with many different home devices including, for example, an air conditioner, lighting devices, electronic locks, door closures, and others.

The invention will now be described in the foregoing, in some specific, non-limiting embodiments, illustrated in the annexed drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates frequency bands allocation for xDSL systems.

Fig 2 is a block diagram illustrating prior art splitterless ADSL system.

Fig. 3 is a block diagram illustrating one embodiment of the multi-point NDSL system of the invention.

Fig. 4 is a block diagram illustrating one embodiment of an NDSL modem of the invention.

Fig. 5 is a flow chart of the operation of the NDSL modem.

Fig. 6 is a block diagram illustrating another embodiment of a multipoint NDSL system according to the invention.

Fig. 7 is a block diagram illustrating another embodiment of an NDSL modem of the invention.

Fig. 8 is a block diagram illustrating another embodiment of a multipoint NDSL system of the invention.

Fig. 9 is a block diagram illustrating another embodiment of an NDSL modem of the invention.

Fig. 10 is a block diagram illustrating another embodiment of a multipoint NDSL system of the invention.

Fig. 11 is a block diagram illustrating one embodiment of an NDSL modem of the invention.

Fig. 12 is a block diagram illustrating another embodiment of a multipoint NDSL system of the invention.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

The present invention concerns systems and devices for a multipoint communication in an ADSL system. The communication technique of the invention allows a subscriber to have multipoint data and voice service with a central office of a telephone service provider, as well as data communication within the SP network, using a number of NDSL modems. In accordance with the present invention, some disadvantages and shortcoming associated with the need for a continuous connection operation mode in prior art ADSL systems, have been substantially reduced.

In one embodiment of a multipoint NDSL system in accordance with the present invention, a number of NDSL modems in the SP are provided, each of which comprises an ADSL upstream transmitter and an ADSL downstream receiver from communication with an ADSL CO modem, as well as an ADSL upstream receiver and TDM control tone receiver for data communication within the SP network. An active NDSL modem transmits a TDM control tone informing other modems in the SP that the line is busy. The control tone carries information about which of the modems is active and which is to receive data in a current communication cycle. Each modem analyzes the control tone information and in case of a match between the received information and the I.D. number of the modem, the modem enables its ADSL upstream receiver. The control tone is at a frequency that is not used for communication with the CO and to which the ADSL CO modem is not receptive and is thus not activated thereby. After termination of data transmission, an active ADSL modem disables its upstream transmitter, stops control tone transmission and switches into a stand-by state.

In accordance with another embodiment of the invention, each NDSL modem within the SP further comprises universal ADSL/VDSL upstream transmitter and VDSL upstream receiver for high speed home data network communication.

In accordance with yet another embodiment of the invention, the SP comprises one or more *"VDSL-ready"* NDSL modems, each of which comprises a VDSL downstream receiver for high speed communication with a VDSL CO equipment (VDSL systems are expected to replace standard ADSL CO equipment used today).

In accordance with a further embodiment of the invention, the SP comprises one or more N.LITE modems, each of which may transmit and receive line signals within the ADSL upstream frequency band to support data communication within an SP network.

In accordance with another embodiment of the invention, the SP comprises one or more N.LITE set-up boxes, each of which is coupled to the subscriber telephone line. Each N.LITE set-top box comprises an N.LITE modem and a RF transceiver, to permit radio communication with a number of different devices and mechanisms within the SP.

The invention will be further illustrated below with reference to the annexed drawings. In different drawings, like components are designated with like reference numerals and where applicable, the reader is referred to the description of previous drawings for explanations of the nature and function of components.

Reference is first being made to Fig. 3 illustrating one embodiment of a multipoint NDSL system **301**. A number of subscriber premises **203** are each coupled to a CO **209** by a telephone cable **217** comprising a plurality of twisted pair subscriber telephone lines **207**. At each such subscriber premise **203** which may be a residence, a small office, etc., there are premise equipments including, for example, personal computers (PCs) **225** (two in this specific example), a printer **227**, a facsimile machine **221** and telephone devices **223**. One of the PCs **225** is connected to printer **227** by a parallel port cable **229**. NDSL

modems **305** are connected directly to the telephone line **207** and each is connected through an Ethernet cable **224** to one of the PCs **225**. Fax **221** and telephone devices **223** are connected to the telephone line **207** through a microfilter **219**. CO **209** includes an ADSL office equipment **211**, data switch **235** linked to a data network **215**, and a voice switch **237** linked to voice network **213**. Each twisted pair subscriber telephone lines **207** is coupled to a POTS splitter **231**, which is coupled to the voice switch **237** and to an ADSL office modem **233**.

Each NDSL modem **305** may communicate both with the ADSL office modem **233** as well as with other home NDSL modems **305** included within the same premise. When communicating with CO **209**, NDSL modem **305** transmits upstream data with a bit rate up to 1 Mb/s and receives downstream data with a bit rate up to 10 Mb/s. An NDSL modem **305** may analyze line signals and communication protocols in accordance with existing ADSL standards (T1E1.413 or ITU G.992.1).

During data transmission with CO, downstream data is transmitted within the ADSL downstream frequency band **105**, and upstream data transmits inside the ADSL upstream frequency band **103**. During periods of no data transmission between CO and any of the NDSL modems, ADSL upstream frequency band **103** may be used for network communications within the SP.

The data network communication between PCs **225** may utilize the half-duplex protocol, data packages being transmissible in two directions, with time division multiplexing (DTM). Typically only ADSL upstream frequency band **103** is used with a bit rate up to 1.5 Mb/s. The NDSL modem **305** may make use of the same DMT line signals and different synchronization signals as in hitherto existing ADSL standard.

Reference is now being made to Fig. 4, showing a block diagram of an ADSM modem **305** in accordance with an embodiment of the invention. Modem **305** comprises an ADSL upstream receiver **403**, an ADSL downstream receiver **405**, an ADSL upstream receiver **407**, a data interface circuit **409**, a communication processor **411**, a control tone receiver **413**, a high impedance

amplifier **415**, a line transformer **417** and a control tone transformer **419**. A primary winding of the line transformer **417** is coupled to the subscriber telephone line **207** from a high pass filter capacitor **423** into a primary winding of control tone transformer **419**. A secondary winding of the line transformer **417** is coupled to the input of an ADSL upstream receiver **403**, to an input of the ADSL downstream receiver **405** into an output of the ADSL upstream transmitter **407**. A secondary winding of the control tone transformer **419** is coupled to the input of the high impedance amplifier **415**, the output of which is connected to the input of the TDM control tone receiver **413**. An input of the ADSL upstream transmitter **407**, an output of the ADSL upstream receiver **403** and an output of the ADSL downstream receiver **405**, are connected to the data interface circuit **409**, by means of digital buses **425, 427** and **429**. Data interface circuit **409** is coupled to the SP equipment by an Ethernet cable **224**. A communication processor **411** is coupled to the ADSL upstream receiver **403**, to ADSL downstream receiver **405**, to ADSL upstream transmitter **407**, to control tone receiver **413** and to switch **433** that connected in parallel to primary winding of control tone transformer **419**.

Reference is now being made to Fig. 5 showing a flow chart of operation of the NDSL modem **305**. At the start of operation **501**, the NDSL modem goes into a standby state **503**. In this stage, switch **433** is open and the end NDSL modem **305** has a high input impedance inflicted by the high impedance amplifier **415** and low frequency control tone transformer **419**. This allows to link a plurality of NDSL modems to the same subscriber telephone line **207**. In this stage ADSL upstream transmitter **407**, ADSL upstream receiver **403** and ADSL downstream receiver **405** are disabled. Against this, control tone receiver **413** is enabled permitting communication processor **411** to analyze the output signal of control tone receiver **413** as well as signals from digital interface circuit **409**. From the standby state **403**, the NDSL modem enters into state **505** and in this state the output signal of control tone receiver **413** is analyzed. If a control tone is received, NDSL modem enters to state **507**; if not, to state **509**. In state **507** a communication

processor **411** analyzes information carried by the control tone and enters state **511** to analyze the received data. If communication processor establishes a match between received data and its own I.D., NDSL modem enters state **513** in which it may communicate with another home NDSL modem; if not, the modem switches back to a standby state **503**. In state **513**, which is the first communication state, the ADSL upstream receiver **403** is enabled permitting communication in a half-duplex protocol **515** and subsequently turning on ADSL upstream transmitter **517**. At the next state **519** a transmission-receiving mode between two NDSL modems is enabled, permitting receipt and transmission of data packets. After transmission or receiving all data packets, the NDSL modem communicates to establish whether a communication cycle has ended or not (state **521)** if not, the NDSL modem continues to transmit or receive additional data packets. If the communication cycle ends, the NDSL modem disables the upstream receiver and the upstream transmitter and stops transmission of control tone (state **523**) to inform other devices that the telephone line is now not busy. At a subsequent state **525**, the NDSL modem is disconnected from the line and enters into a standby state **503**.

If in state **505** control tone is not received, the NDSL modem enters state **509**. If a PC is asking for communication, the NDSL modem enters state **531**; if not – the modem goes back to standby state **503**. In state **531**, the NDSL modem is connected to the telephone line, with upstream transmission being enabled and then enters state **533** in which control tone transmission is initiated to inform any other device that the line is busy. In a subsequent state **535**, the nature of communication needed by the PC is defined. In the case of communication with another NDSL modem **537**, information about I.D. number of modem is transmitted (state **539**), and then NDSL modem enters state **513** to enable ADSL upstream receiver. In the case of communication with CO **545**, standard ADSL duplex protocol may be used and the modem may operate in an FDM mode. Otherwise, the modem enters state **547** in which it asks the PC whether the communication cycle has ended. If the communication cycle has ended, the modem switches to state **523**. If not, it switches to ADSL transmission/receiving state **545**.

Reference is now being made to Fig. 6 illustrating another embodiment of a multipoint NDSL system **601**. A number of subscriber premises **203** are connected to the CO **209** through a telephone cable **217** comprising a plurality of twisted pairs of subscriber telephone lines **207**, similarly as in the embodiment shown in Fig. 3. A subscriber premise **203** comprises a communication equipment similar to those shown in Fig. 3 and further video equipments consisting of a video recorder **653** and a HDTV television **665** and a DVD player **651**. Each of these video devices is coupled to a high speed NDSL modem **605** by a digital cable **324**. Each of modems **605** is directly connected to telephone line **207**. CO **209** is similar to that shown in Fig. 3.

Each of a high speed NDSL modems **605** can communicate with the ADSL office modem **233** as well as with other high speed NDSL modem **605** of with NDSL modems **305**. For communication with CO **209**, modems **305** and **605** may transmit upstream data with a bit rate up to 1 Mb/s and receive downstream data with a bit rate up to 10 Mb/s.

The high speed NDSL modem **605** comprises universal ADSL/VDSL upstream transmitter and a ADSL downstream receiver for communication with the ADSL office modem, and an ADSL upstream receiver, a VDSL upstream receiver and a control tone receiver for home data network communication. The universal ADSL/VDSL transmitter can transmit DTM signal only in the ADSL upstream frequency band **103** for communication with the ADSL office modem, as well as in the VDSL upstream frequency bands **111** and **113** for communication with other high reference speed NDSL modems within the subscriber's premise.

A block diagram of a high speed NDSL modem **605** in accordance with an embodiment of the present invention is shown in Fig. 7. Like components to those of the NDSL modem **305** shown in Fig. 4 were given like reference numerals and the reader is referred to the description of Fig. 4 for explanation of their nature and function. The main difference between modem **605** and **305** lies in the inclusion of VDSL upstream receiver **451** and in the inclusion of an ADSL/VDSL upstream

transmitter **477** instead of transmitter **407** in modem **305**. The principles of operation of this modem are similar to those of modem **305**, *mutatis mutandis*.

Reference is now being made to Fig. 8 showing a system **801** in accordance with another embodiment of the invention. Here again, like components to those of previous figures have been given like reference numerals and the reader is referred to the description below for explanation of their nature and function. In this embodiment, the subscriber premise **203** comprises VDSL-ready NDSL modems **805**. Modem **805** permits communication with the standard ADSL office equipment **211** as well as with VDSL office equipment **811**, which may replace the ADSL office equipment **211** in the future. Furthermore, similarly as in the case of modems **305** and **605**, modem **801** also permits communication with other NDSL modems **805**, as well as with modems **605** or **305** within the subscriber's premise. Modem **805** may use line signals and communication protocols in accordance with existing ADSL standards (T1E1.413 or ITU G.992.1). Communication with a CO ADSL equipment **211**, may be similar to the case of modems **305** or **605**. In case of communication with a VDSL office equipment **811**, modem **805** may transmit upstream data with a bit rate up to 28 Mb/s and receive downstream data with a bit rate up to 50 Mb/s. When communicating in the VDSL mode, modem **805** may use line signals in communication protocols of existing VDSL standards.

For data communication within the SP, modem **805** may utilize half-duplex protocol in both ADSL upstream frequency band **103**, as well as in VDSL upstream frequency bands **111** and **113**. Inter-premise data exchange may have a bit rate up to 12 Mb/s (when communicating only in the first VDSL upstream band) or up to 28 Mb/s (when utilizing both bands **111** and **113**). The DTM line signals utilized by modem **805** may be transmitted both in the ADSL and VDSL upstream bands.

A VDSL-ready NDSL modem **805** comprises universal ADSL/VDSL upstream transmitter and an ADSL downstream receiver for communication with an ADSL office modem, a VDSL downstream receiver for communication with VDSL office modem, and a ADSL upstream receiver, a VDSL upstream receiver and a control tone receiver for home data network communication. A universal

ADSL/VDSL upstream transmitter is able to transmit DTM signals in the ADSL upstream frequency band **103** for communication with ADSL office modem, in the VDSL upstream bands **111** and **113** for communication with a VDSL office modem, and in both the ADSL and VDSL upstream frequency bands **103**, **111** and **113** for communication with other VDSL-ready NDSL modems.

A block diagram of a VDSL-ready NDSL modem **805** is shown in Fig. 9. Like components to those of modems **305** and **605** shown in Figs. 4 and 6 having like reference numerals. This modem is similar to modem **405** with the main difference being the addition of the VDSL downstream receiver **453**. Otherwise, its structure and mode of operation are similar to those of modem **605** and in this connection the reader is referred to the description below.

A multipoint NDSL system **1001** in accordance with another embodiment of the invention can be seen in Fig. 10. A subscriber premise, in accordance with this embodiment, comprises an N.LITE modems **1005**, each of which is connected directly to a telephone line **207**. Each N.LITE modem **1005** may communicate with other N.LITE modems **1005** or with other NDSL modems, e.g. modem **605**, located in the subscriber's premise. Thus, an N.LITE **1005** may support only home data network communication.

For home data network communication, the N.LITE modem **1005** uses a half-duplex protocol and the information transmits in two directions of data packets, with time division multiplexing (TDM). The N.LITE modem **1005** communicates, in this embodiment, only within the ADSL upstream frequency band **103**. The data exchange between N.LITE modems **1005** may thus have a bit rate up to 1.5 Mb/s. Each of the N.LITE modems **1005** may be linked to a home digital equipment such as a printer **227** or a scanner **1007**.

A block diagram of an N.LITE modem **1005** can be seen in Fig. 11. N.LITE modem **1005** differs from modem **305** (Fig. 4) in that the former does not include the ADSL downstream receiver **405**. Otherwise its mode of operation is similar to that of modem **305**, *mutatis mutandis*.

A multipoint NDSL system **1201** in accordance with another embodiment of the invention can be seen in Fig. 12. In this embodiment, one of N.LITE modems **1005** is included within an NDSL set-up box **1205** which comprises also an RF transceiver **1207** for controlling, through transmission of radio signals, of a number of mechanical and electrical devices in the home.

CLAIMS:

1. A communication system comprising:

- a central office (CO) of a communication service provider and at least one subscriber premise (SP), each SP being linked to a CO by a subscriber-associated communication line comprising a twisted pair telephone line;
- at least one xDSL modem in the CO coupled to said subscriber-associated communication line; and
- a plurality of communication devices in each SP, said devices comprising one or more telephone devices connected to the communication line and at least one network DSL (NDSL) modem associated with a computerized device, the NDSL modem being connected to said communication line; each of said modems having an upstream transmitter and a downstream receiver for communication with the CO and an upstream transmitter and an upstream receiver for communication with other NDSL modems within the SP.

2. A communication system according to Claim 1, wherein said NDSL modem comprises a means for transmitting a control signal to which the CO modem is not receptive and which signals at least one other DNSL modem to be ready to receive data packets.

3. A communication system according to Claim 2, wherein said control signal is at a frequency not used for communication between the NDSL modem and the CO.

4. A communication system according to any one of Claims 1-3, wherein the communication between the NDSL modems and the CO modem is in the ADSL frequency bands.

5. A communication system according to Claim 4, wherein the NDSL modems transmits data to the CO modem in the ADSL upstream frequency band and receive data therefrom at the ADSL downstream frequency band, and exchanges (transmit and receive) data with other NDSL modems within the SP in

the ADSL upstream frequency band during time periods in which none of said modems is communicating with the CO.

6. A communication system according to any one of Claims 1-4, wherein the NDSL modem comprises also a VDSL upstream transmitter and a VDSL upstream receiver for communication with other NDSL modems within the SP subscriber premise in the VDSL upstream frequency band.

7. A communication system according to any one of Claims 1-6, comprising a universal ADSL/VDSL upstream transmitter and a VDSL downstream receiver for high speed communication within the VDSL frequency bands with the CO.

8. A communication system according to any one of Claims 1-4, comprising at least one N.LITE modem associated with a computerized device, the modem comprising an ADSL upstream transmitter and an ADSL upstream receiver for communication with only other N.LITE or NDSL modems within the SP.

9. A communication system according to Claim 8, wherein at least one of said N.LITE modems is comprised within an NDSL set-up box which comprises also an RF transceiver for control, through radio frequency transmission within the SP.

10. A local network installed in premises of a subscriber of a communication service, the network being linked to an xDSL modem of a central office (CO) of a communication service provided by a communication line comprising a twisted pair telephone line, the network comprising:

a plurality of communication devices comprising one or more telephone devices connected to the communication line and at least one network DSL (NDSL) modem associated with a computerized device, the NDSL modem being connected to said communication line; each of said modems having an upstream transmitter and a downstream receiver for communication with the CO and an upstream of transmitter and an upstream receiver for communication with other NDSL modems within the SP.

11. A network according to Claim 10, wherein said NDSL modem comprises means for transmitting a control signal to which the CO modem is not receptive

and which signals at least one other DNSL modem to be ready to receive data packets.

12. A network according to Claim 11, wherein said control signal is at a frequency not used for communication between the NDSL modem and the CO.

13. A network according to any one of Claims 10-12, wherein the communication bands between the NDSL modems and the CO modem is in the ADSL frequency bands.

14. A network according to Claim 13, wherein the NDSL modems transmits data to the CO modem in the ADSL upstream frequency band and receive data therefrom at the ADSL downstream frequency band, and exchanges (transmit and receive) data with other NDSL modems within the SP in the ADSL upstream frequency band during time periods in which none of said modems is communicating with the CO.

15. A network according to any one of Claims 10-13, wherein the NDSL modem comprises also a VDSL upstream transmitter and a VDSL upstream receiver for communication with other NDSL modems within the SP subscriber premise.

16. A network according to any one of Claims 10-15, comprising a universal ADSL/VDSL upstream transmitter and a VDSL downstream receiver for high speed communication within the VDSL frequency bands with the CO.

17. A network according to any one of Claims 10-13, comprising at least one N.LITE modem associated with a computerized device, the modem comprising an ADSL upstream transmitter and an ADSL upstream receiver for communication with only other N.LITE or NDSL modems within the SP subscriber premise.

18. A network according to Claim 17, wherein at least one of said N.LITE modems is comprised within an NDSL set-up box which comprises also an RF transceiver for control, through radio frequency transmission, of appliances with the SP subscriber premise.

19. A home network DSL (NDSL) modem comprising:

- an upstream transmitter and a downstream receiver for communication with an xDSL modem placed at a central office (CO) of a communication service provider through a twisted pair telephone line linking the NDSL modem and the xDSL CO modem, and comprising an upstream transmitter and an upstream receiver for communication with other NDSL modems included within the same subscriber premise.

20. A modem according to Claim 19, comprising a means for transmitting a control signal to which a CO modem is not receptive for signaling at least one other NDSL modem to be ready to receive data packets.

21. A modem according to Claim 20, wherein said control signal is at a frequency not used for communication between the NDSL modem and the CO.

22. A modem according to any one of Claims 19-21, wherein the upstream transmitter and upstream receiver for communication with the xDSL modem of the CO, are transmitting and receiving, respectively in the ADSL frequency bands.

23. A modem according to Claim 22, wherein data transmission to the CO xDSL modem in the ADSL upstream frequency band and data transmission therefrom is in the ADSL downstream frequency band, and is capable of exchanging data with other NDSL modems within the home location in the ADSL upstream frequency band.

24. A modem according to Claim 23, wherein said upstream transmitter and said downstream receiver can communicate with the CO xDSL modem in VDSL upstream and downstream frequency bands, respectively.

25. An NDSL model according to any one of Claims 19-24, comprised within an NDSL set-up box which comprises also an RF transceiver for control, through radio frequency transmission, a home device.

ABSTRACT

A communication system is provided. It comprises a central office (CO) of a communication service provider and at least one subscriber premise (SP), each SP being linked to a CO by a subscriber-associated communication line comprising a twisted pair of telephone lines, and at least one xDSL modem in the CO coupled to said subscriber-associated communication line. Each SP has a plurality of communication devices, which comprises one or more telephone devices connected to the communication line and at least one network DSL (NDSL) modem associated with a computerized device, the NDSL modem being connected to said communication line; each of said modems having an upstream transmitter and a downstream receiver for communication with the CO and an upstream transmitter and an upstream receiver for communication with other NDSL modems within the SP. Provided is also a novel NDSL modem for use in the above system.

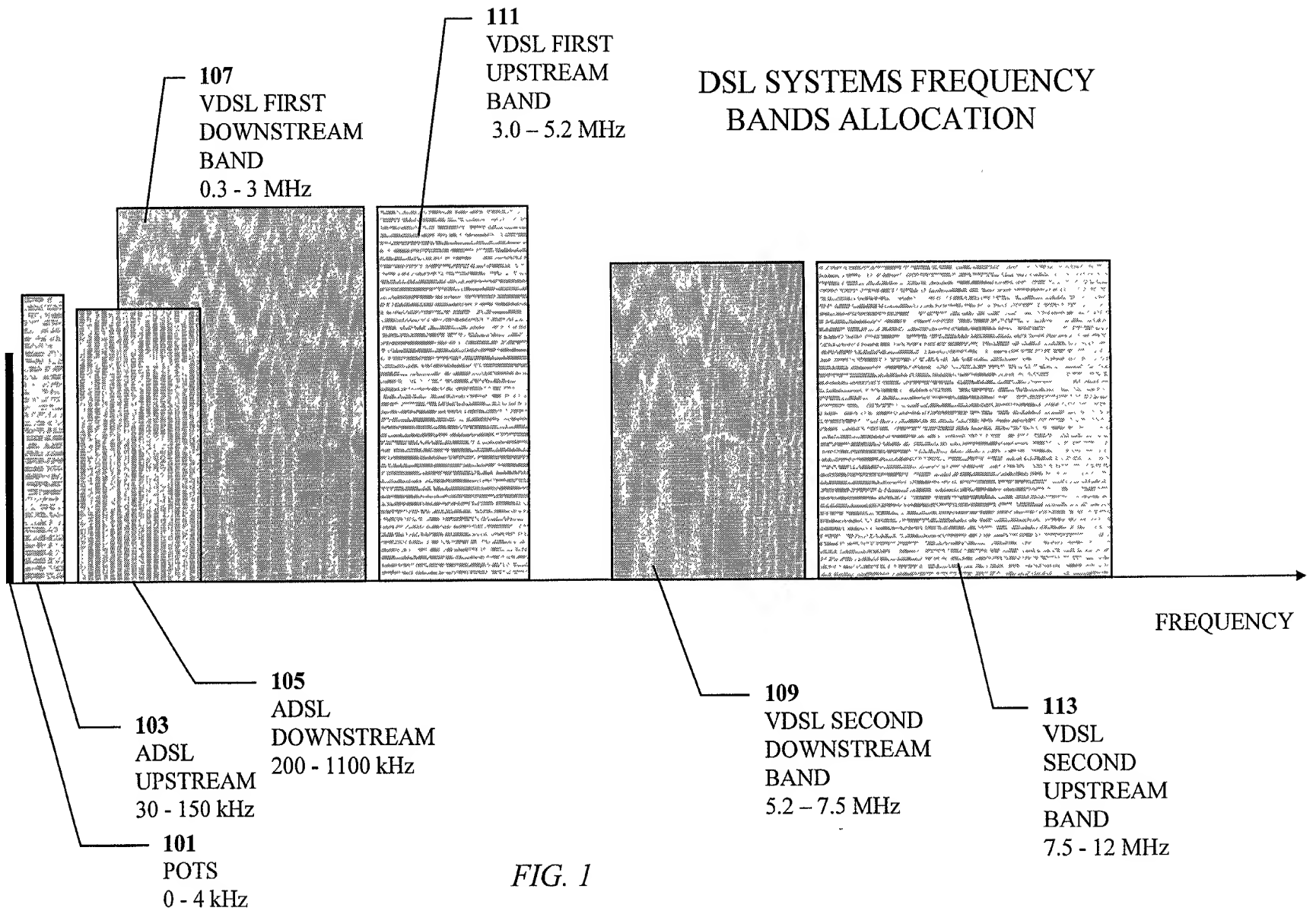
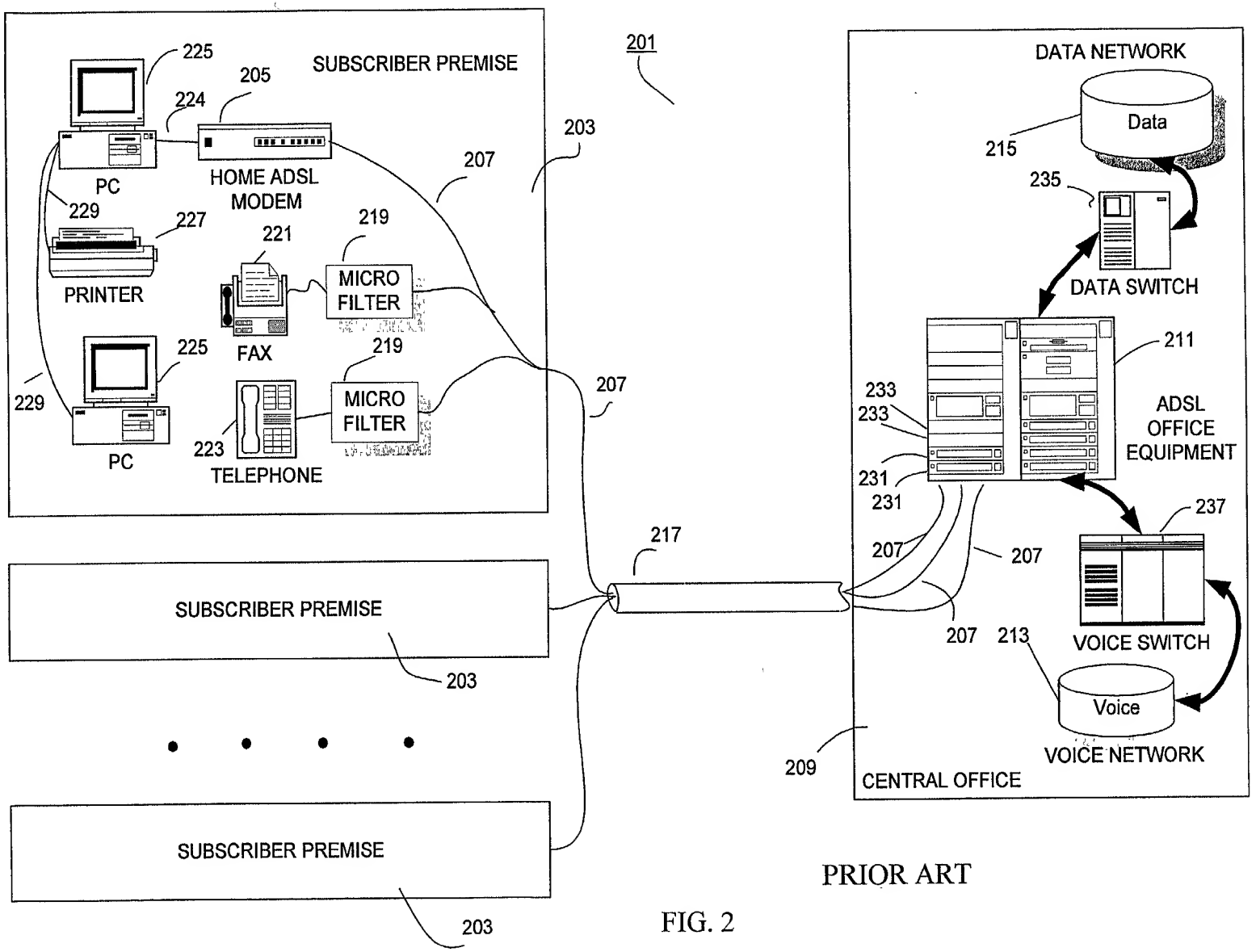
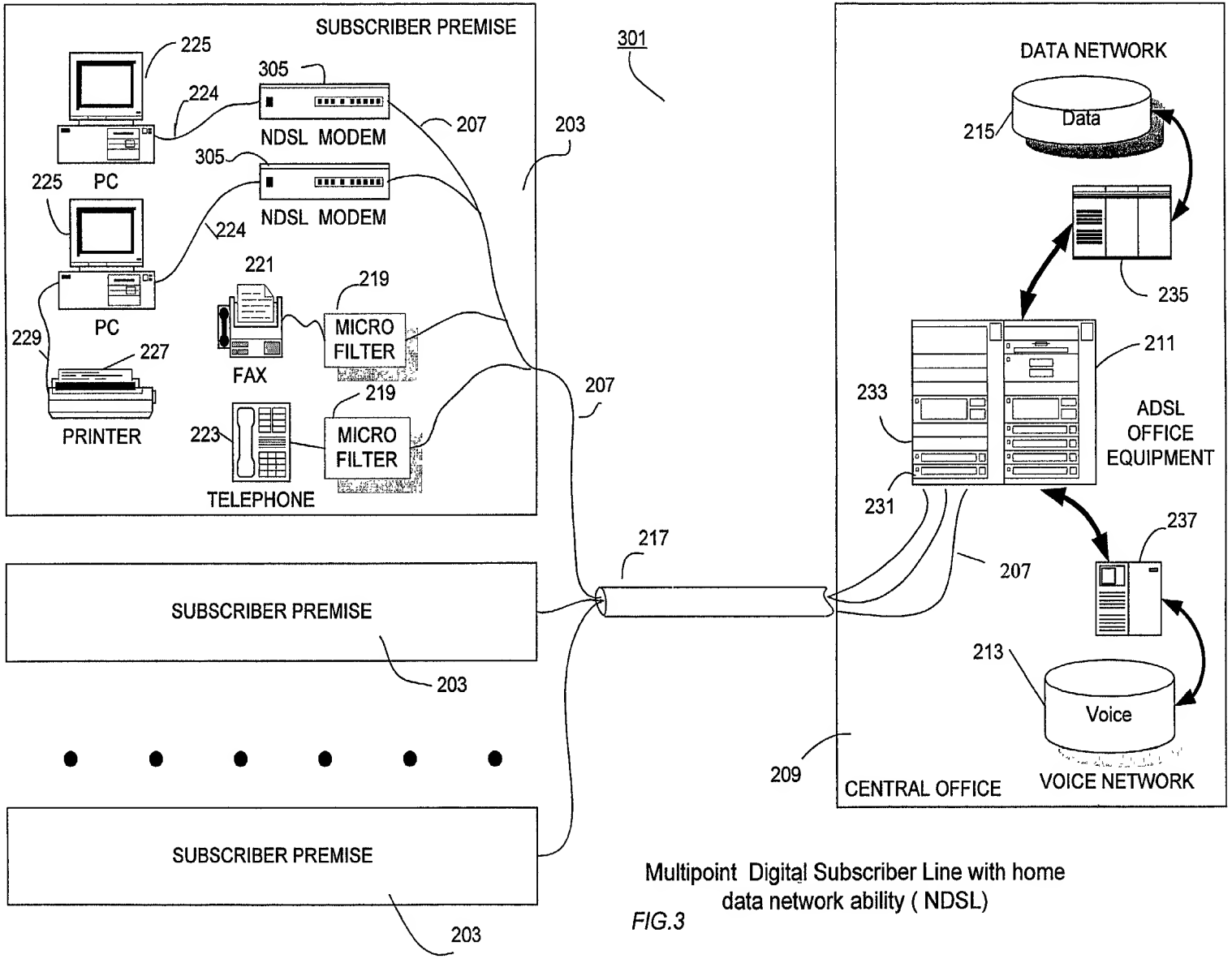


FIG. 1



PRIOR ART

FIG. 2



Multipoint Digital Subscriber Line with home data network ability (NDSL)

FIG.3

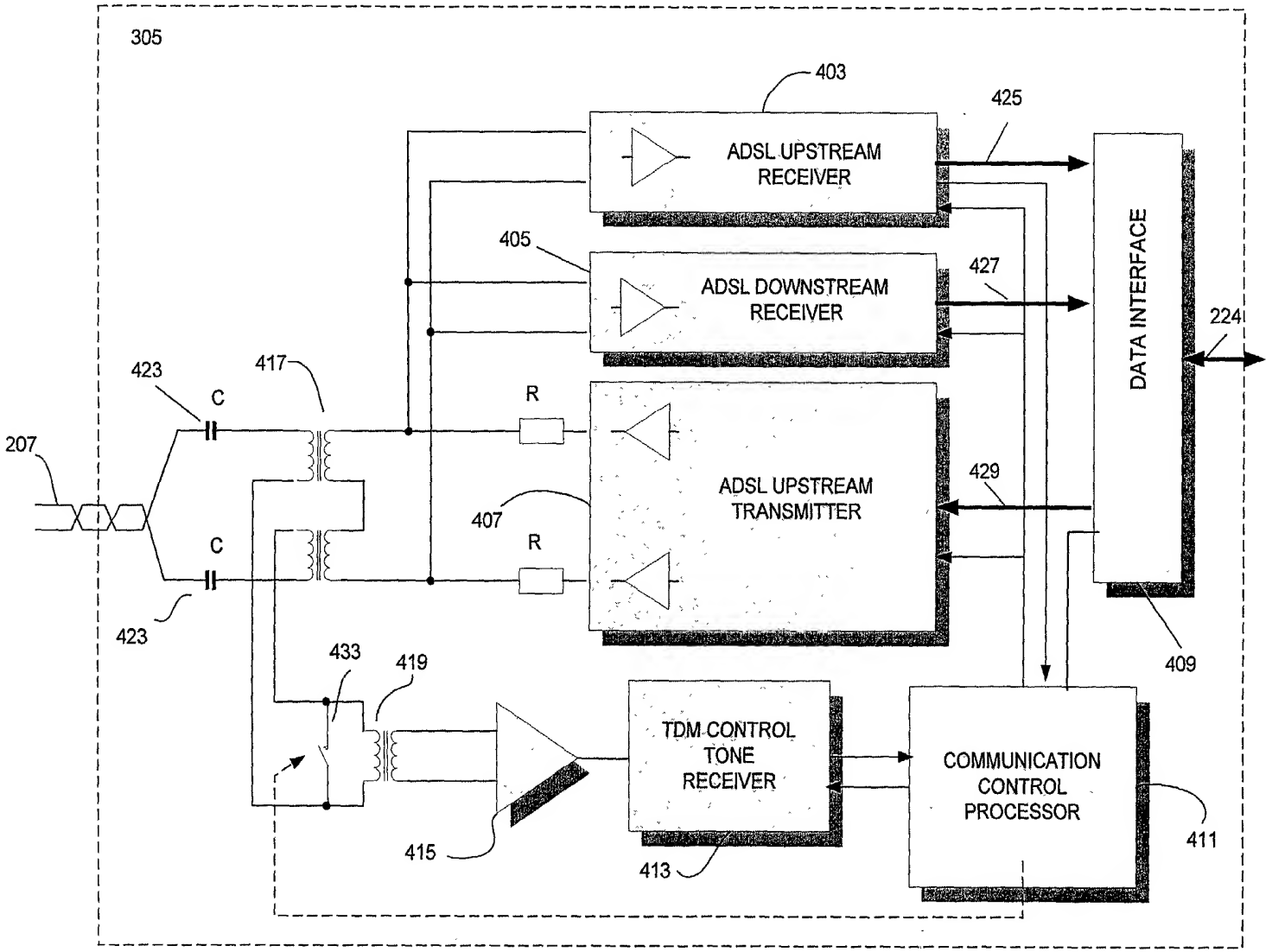


FIG.4

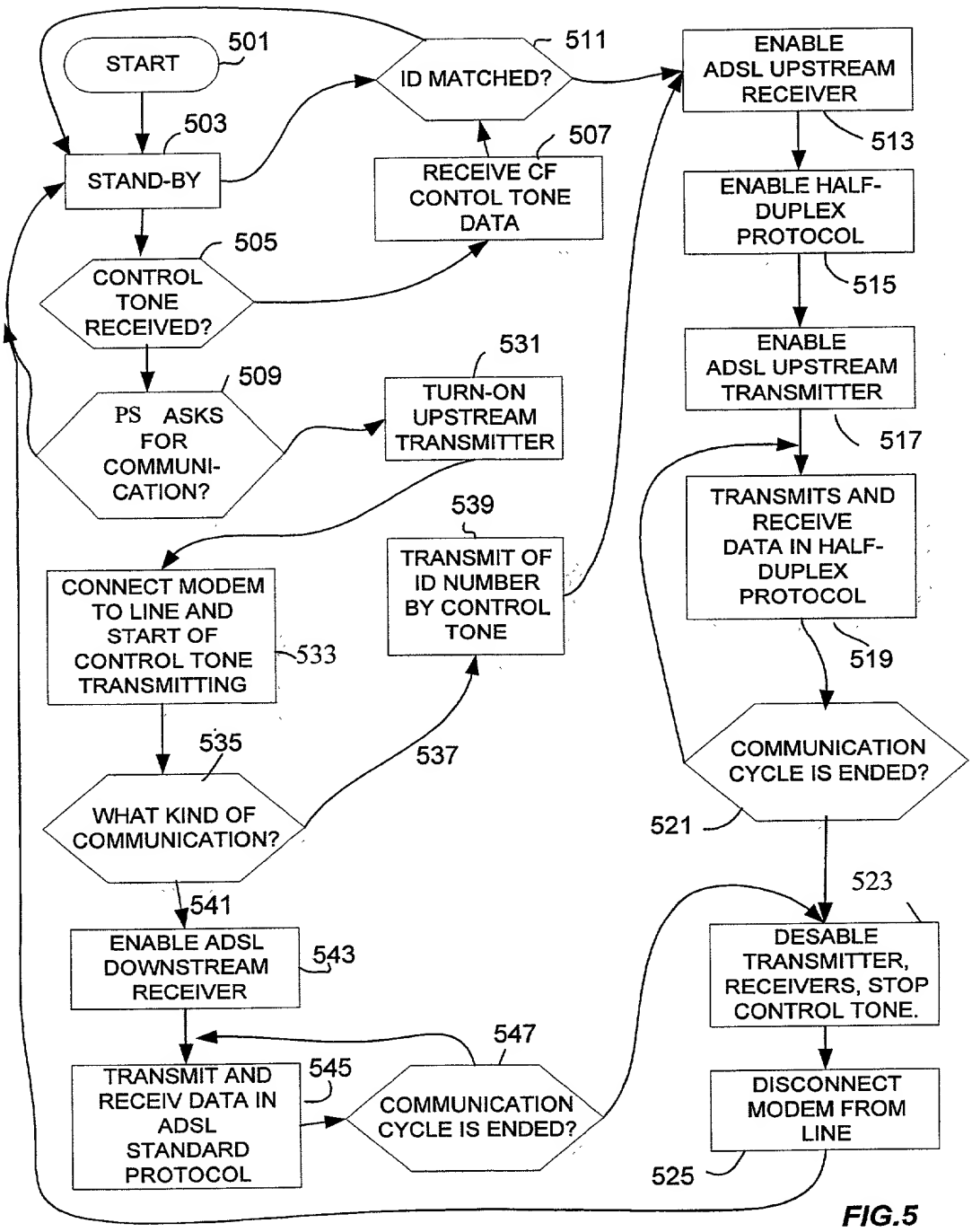

START
501
STAND-BY
503
CONTROL TONE RECEIVED?
505
PS ASKS FOR COMMUNI-CATION?
509
CONNECT MODEM TO LINE AND START OF CONTROL TONE TRANSMITTING
533
WHAT KIND OF COMMUNICATION?
535
537
ENABLE ADSL DOWNSTREAM RECEIVER
541
543
TRANSMIT AND RECEIV DATA IN ADSL STANDARD PROTOCOL
545
COMMUNICATION CYCLE IS ENDED?
547
DISCONNECT MODEM FROM LINE
525
DESABLE TRANSMITTER, RECEIVERS, STOP CONTROL TONE.
523
COMMUNICATION CYCLE IS ENDED?
521
TRANSMITS AND RECEIVE DATA IN HALF-DUPLEX PROTOCOL
519
ENABLE ADSL UPSTREAM TRANSMITTER
517
ENABLE HALF-DUPLEX PROTOCOL
515
ENABLE ADSL UPSTREAM RECEIVER
513
ID MATCHED?
511
RECEIVE CF CONTOL TONE DATA
507
TURN-ON UPSTREAM TRANSMITTER
531
TRANSMIT OF ID NUMBER BY CONTROL TONE
539

FIG.5

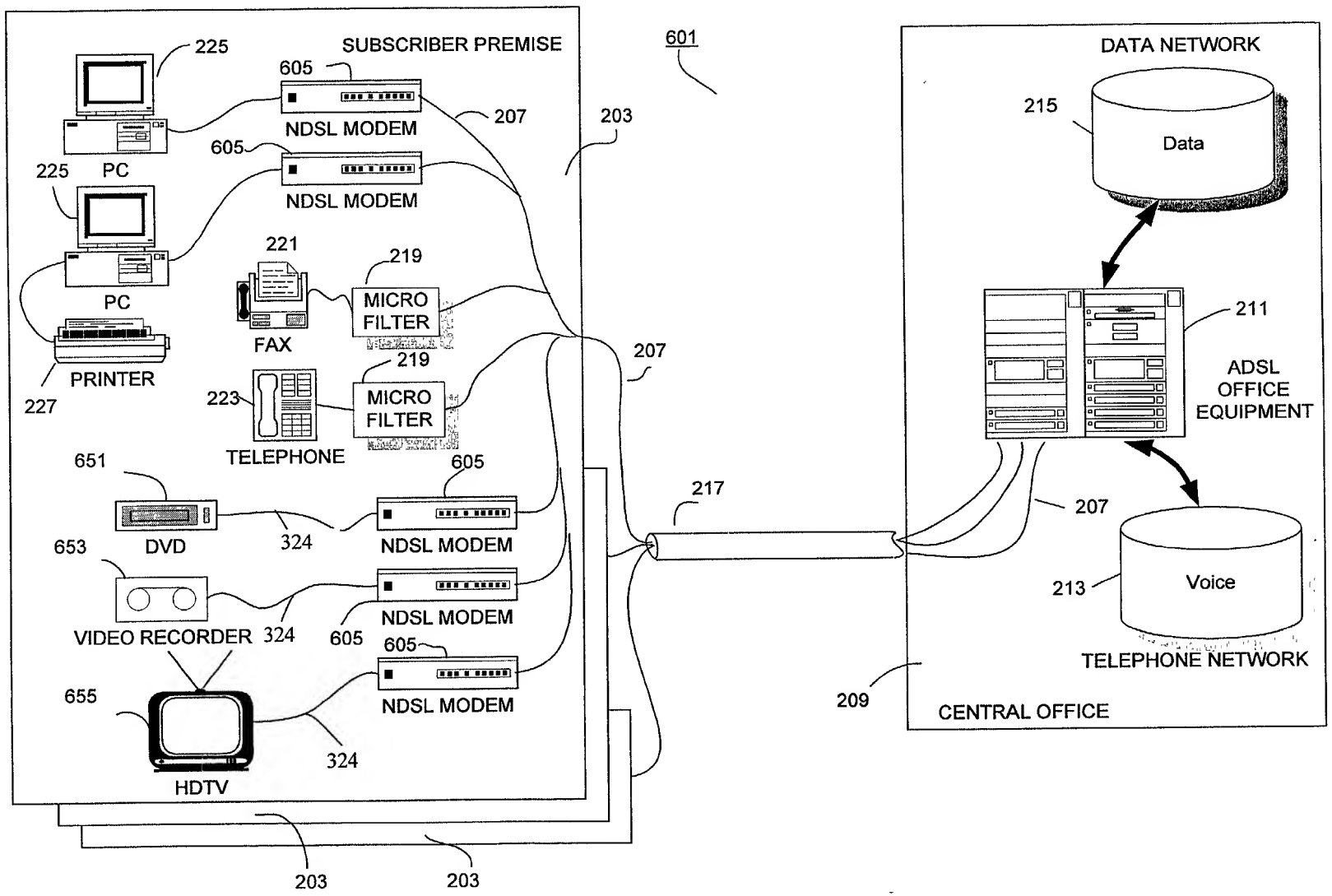


FIG.6

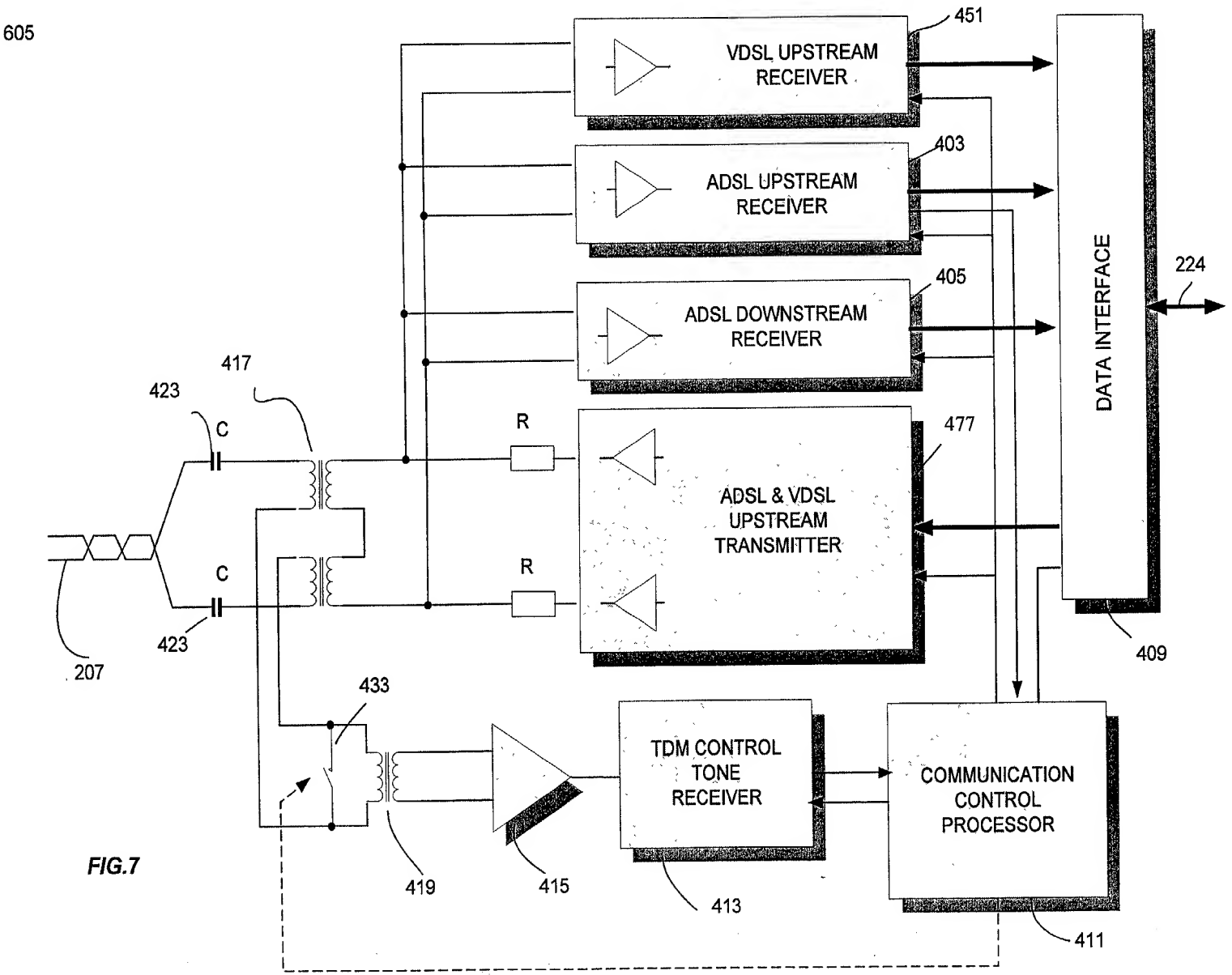
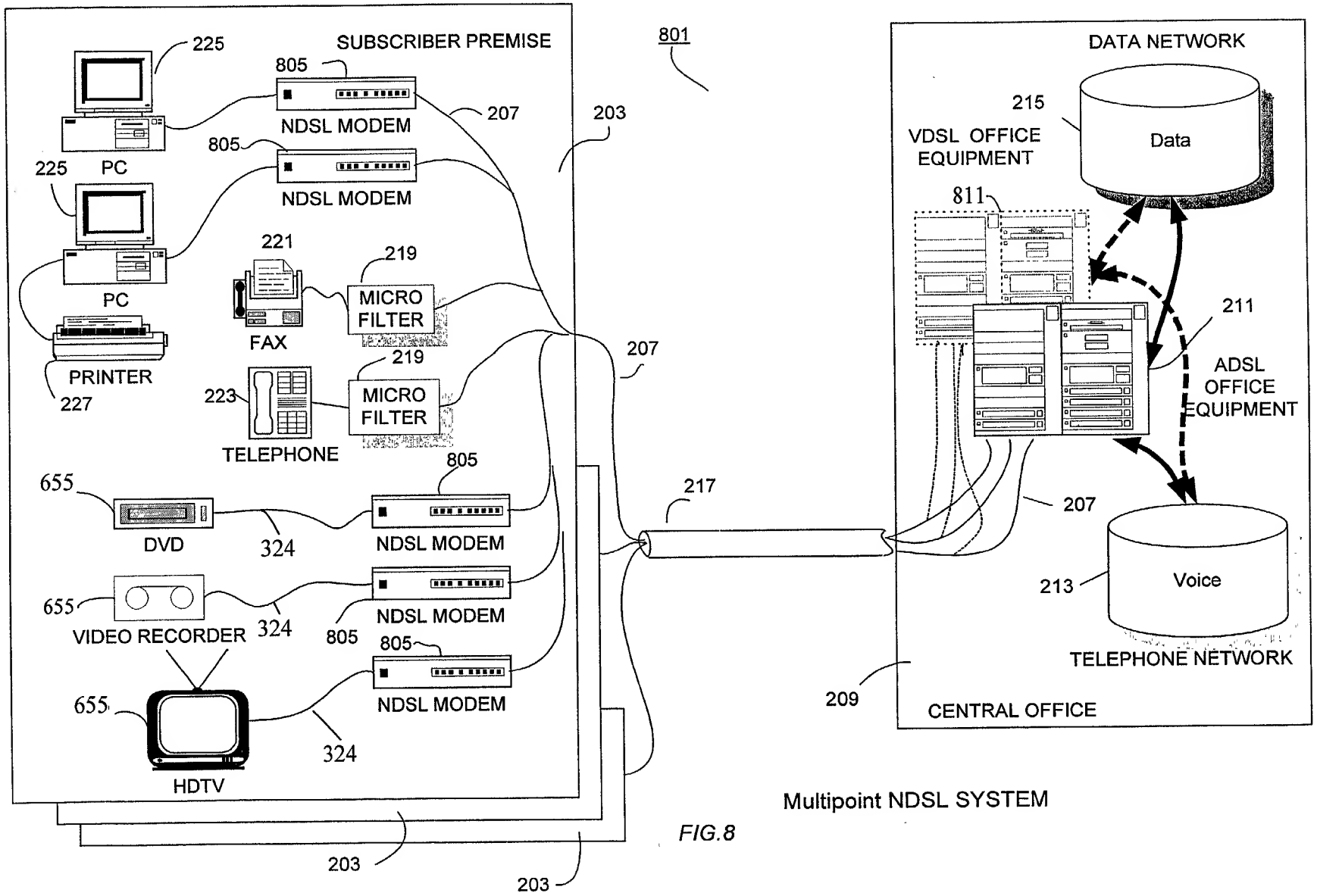


FIG.7



Multipoint NDSL SYSTEM

FIG.8

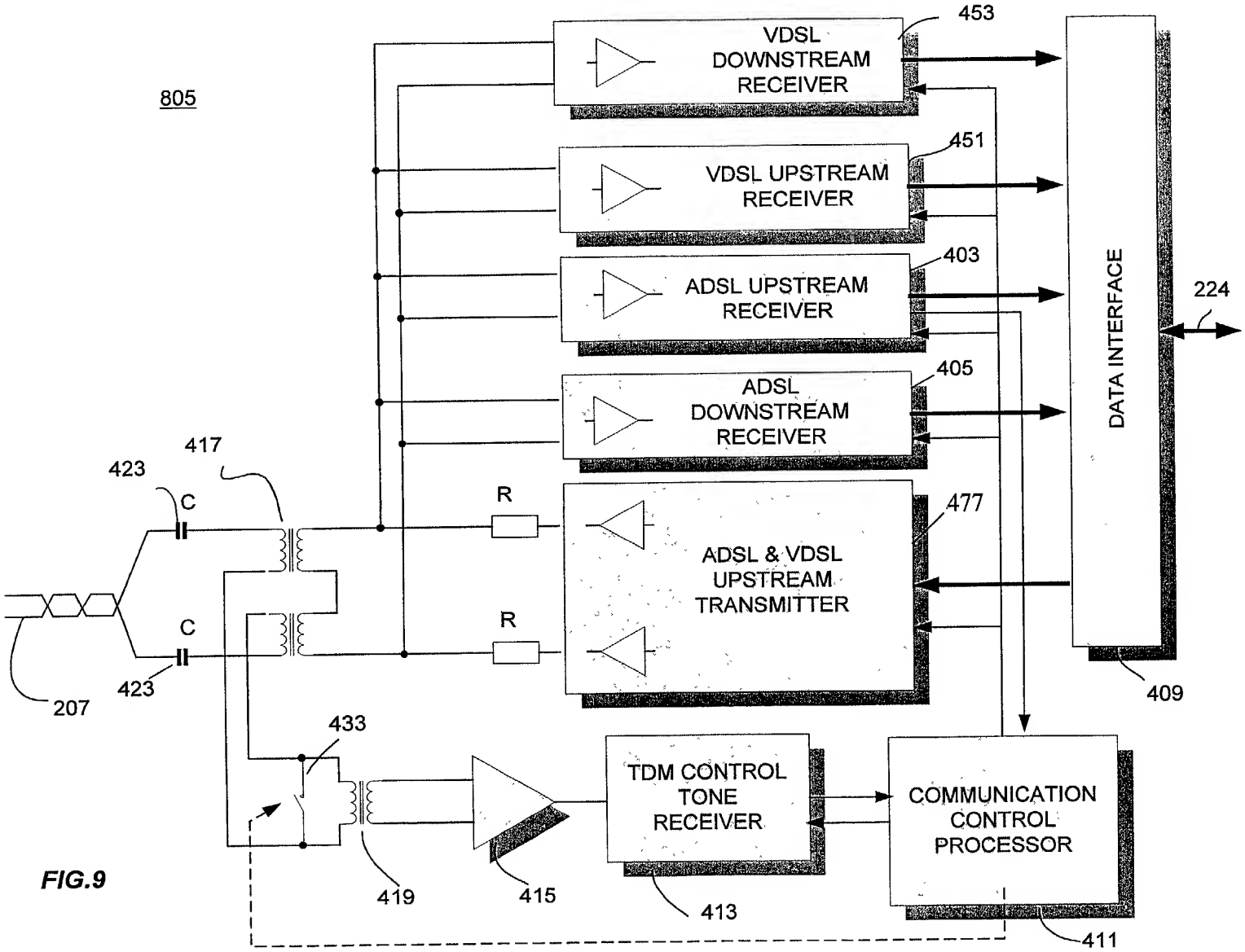
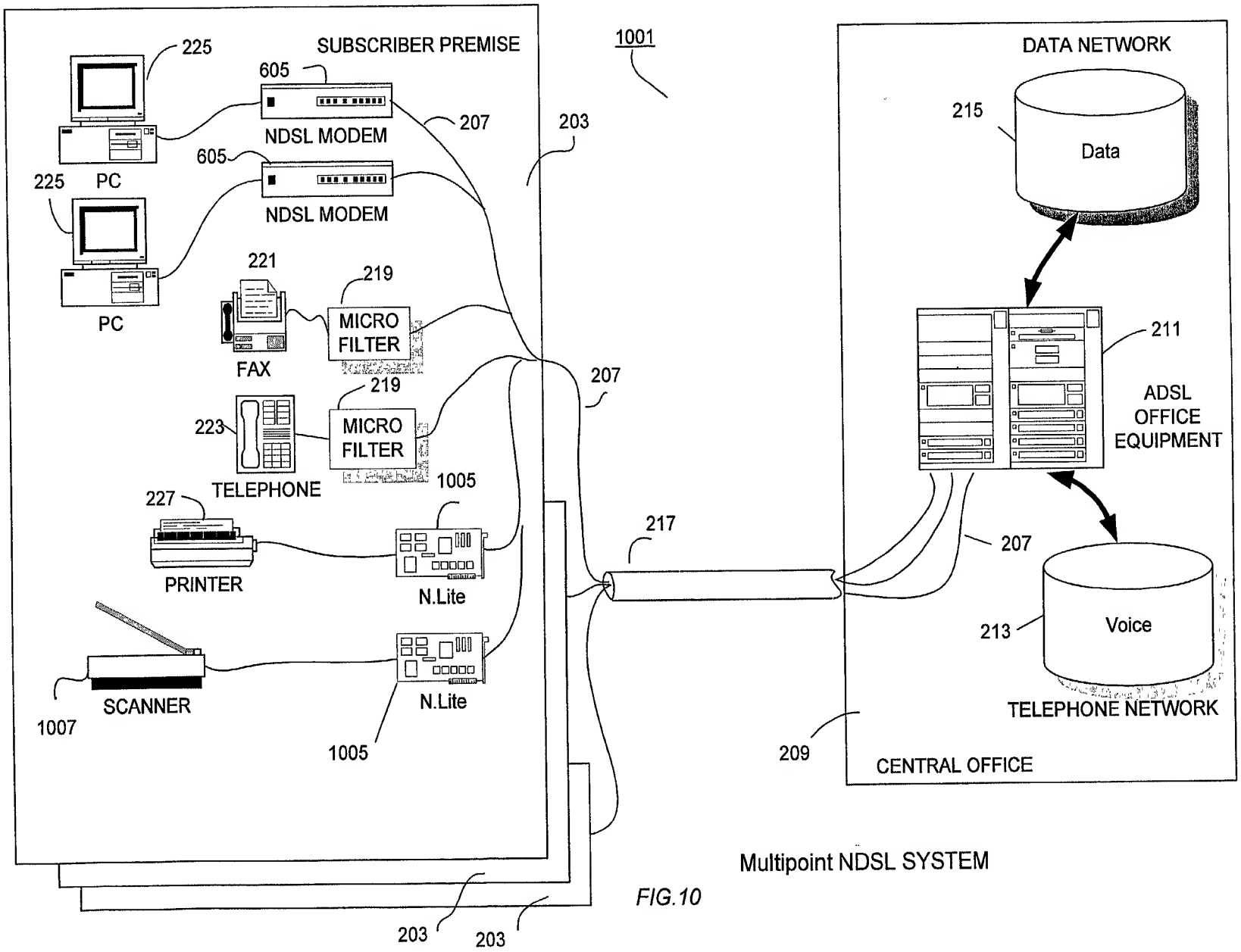

805
VDSL DOWNSTREAM RECEIVER
453
VDSL UPSTREAM RECEIVER
451
ADSL UPSTREAM RECEIVER
403
ADSL DOWNSTREAM RECEIVER
405
ADSL & VDSL UPSTREAM TRANSMITTER
477
DATA INTERFACE
224
409
417
423
C
R
C
R
423
207
433
TDM CONTROL TONE RECEIVER
COMMUNICATION CONTROL PROCESSOR
419
415
413
411

FIG.9



Multipoint NDSL SYSTEM

FIG.10

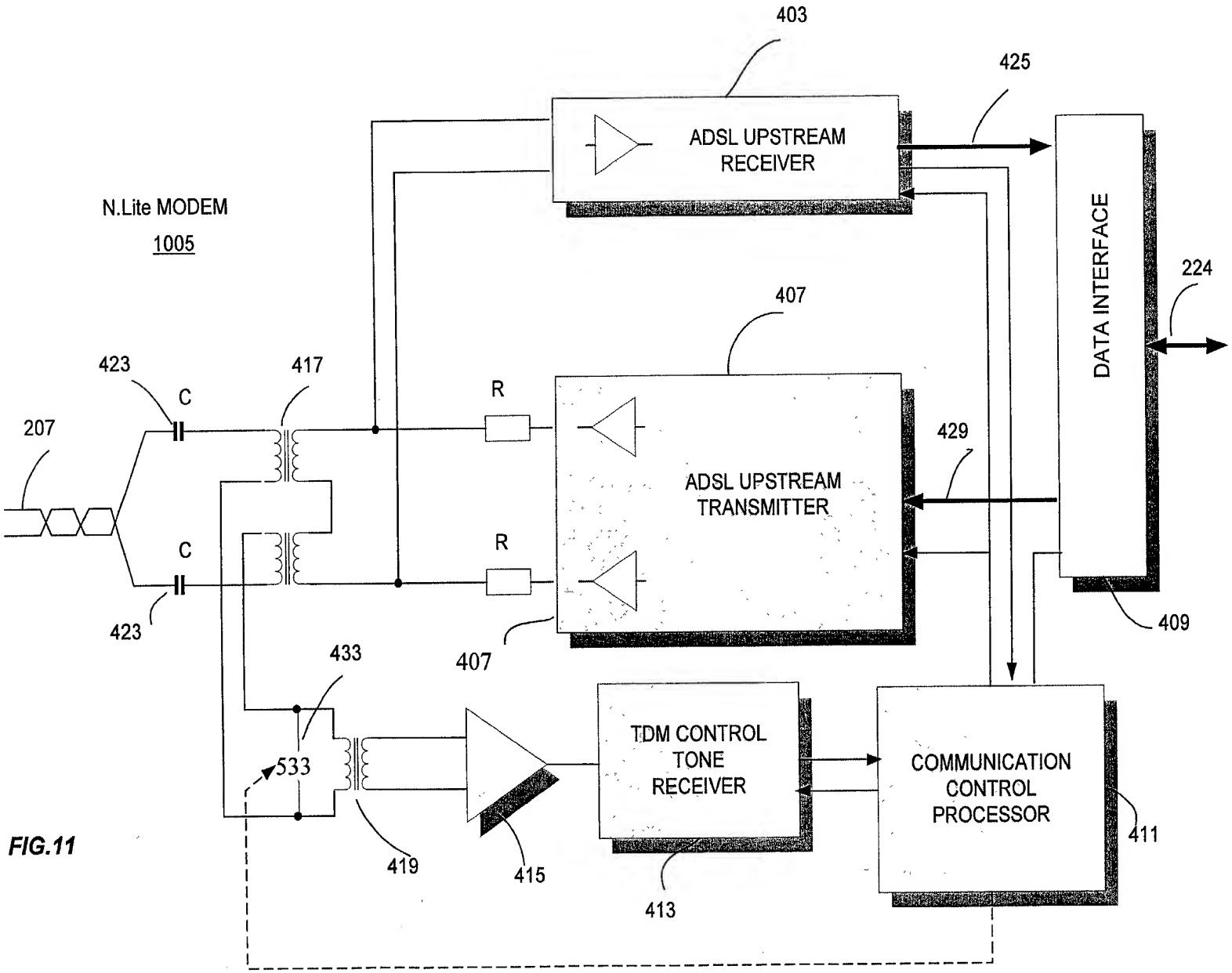
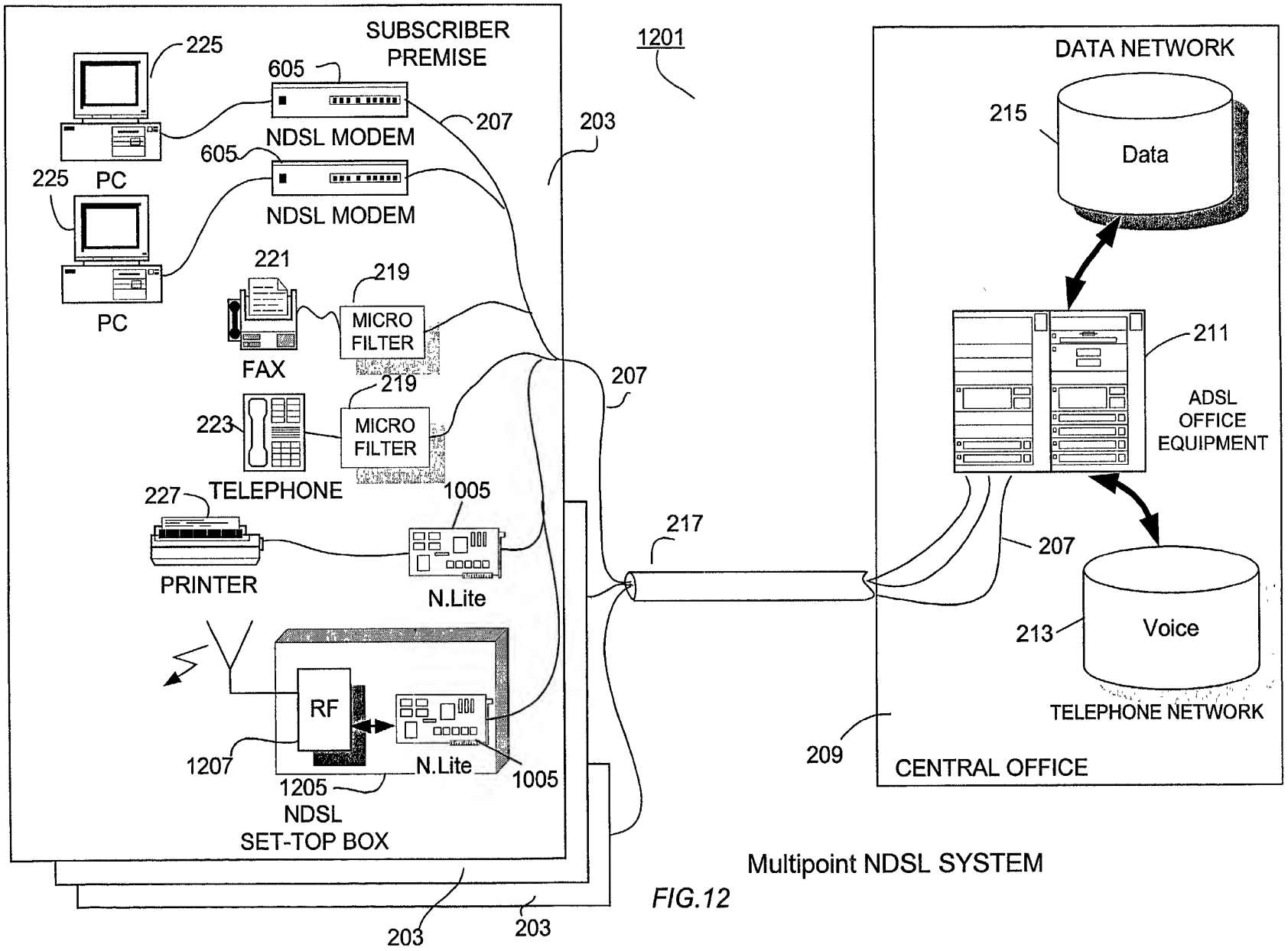


FIG.11



Multipoint NDSL SYSTEM

FIG.12